ELECTRICAL CONDUCTIVITY OF NATURAL STANNIC OXIDE

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ABSTRACT. The electrical conductivities of number of stannic oxide polycrystalline bars prepared from Nigerian cassiterite powder were measured in the temperature range 25°C to 650°C. The activation energy obtained in the high temperature range for three samples studied are 0.42, 0.48, 0.50 eV as against the activation energy of 0.72 eV obtained by Kohnke (1962) in the same temperature range for crystals of Bolivian cassiterite. For thin films of stannic oxide, Niloslavskii (1959) calculates an activation energy of 0.12 eV in the same temperature range.

INTRODUCTION

Cassiterite which is an important mineral of tin has stannic oxide, SnO_2, as its main constituent, crystallises in the tetragonal rutile structure and is strongly resistant to chemical reagents and heat treatment in air or oxygen. It belongs to the structural space group P4/mm having two molecules per unit cell.

Earlier work on stannic oxide has been essentially limited to thin films and coatings (Bauer 1937, Aitchison 1954, Fischer 1954, Ishiguro *et al.* 1958), and powder samples (Ieblanc *et al.*, 1931; Guillery 1932, Foex 1944). The limitations inherent in these measurements due to grain boundaries, inhomogeneities and large surface-to-bulk ratio can be reduced by using polycrystalline solids or single crystals as study specimens. The only investigations reported in this direction are by Kohnke (1952) on three specimens from crystals of natural Bolivian cassiterite, studied in the temperature range 100°C to 500°C and by Lock (1963) on polycrystalline bars of stannic oxide, undoped and doped with antimony, in the temperature range 100°C to 900°C.

The object of the present communication is to give a preliminary report of conductivity measurements on polycrystalline bars of Nigerian cassiterite.

EXPERIMENTAL

(a) *Preparation of samples*

Polycrystalline solid rods were prepared from cassiterite powder by sintering at about 800°C in air. Rectangular slabs were sliced from the rod and ground to plane faces with fine emery powder. In the case of extended contacts, two opposite faces were copper plated. To test for rectification, one slab was prepared with extended contact on one face, and a sharp point contact was maintained at the opposite face.

The sample holder used was made of porcelein base provided with brass electrodes, a modified form of the one used by Dutta (1953).

(b) *Electrical measurements*

Current voltage measurements up to 1.5 volts was made by potentiometer and above it by ammeter and voltmeter. Temperature variation was provided by an electrical furnace. Measurements were made both for forward and reverse currents in the temperature range 25°C to 650°C. Chromel Alumel thermocouple was used for measuring temperature.

RESULTS

The results of measurements are shown in Table I and II and graphs (figs. 1, 2, 3 and 4).

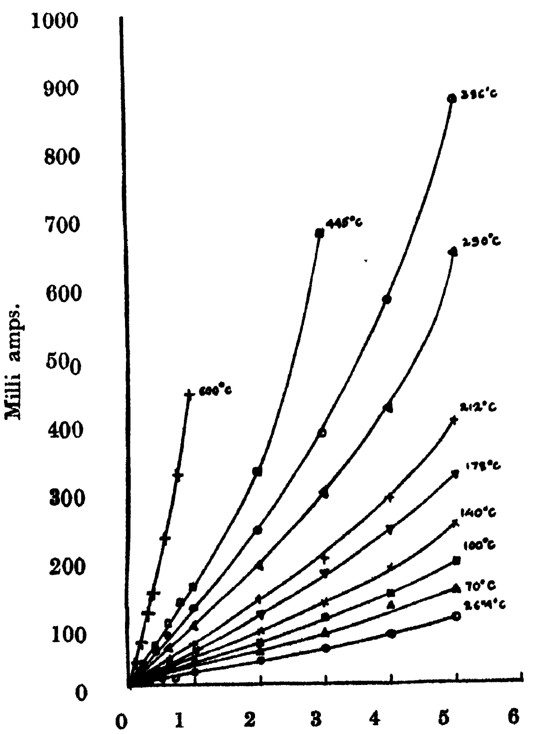

Fig. 1. Current-Voltage characteristic with extended contact at both ends.

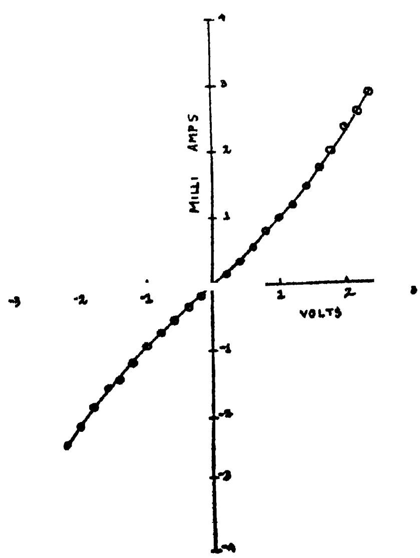

Fig. 2. Current-Voltage characteristic with extended contact at one end and point contact at the other.

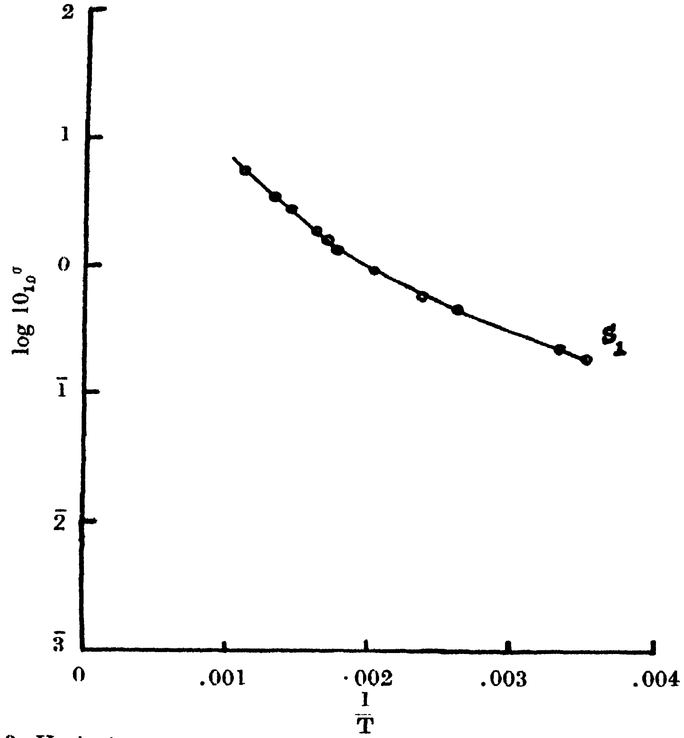

Fig. 3. Variation of conductivity with temperature. for specimen S_1.

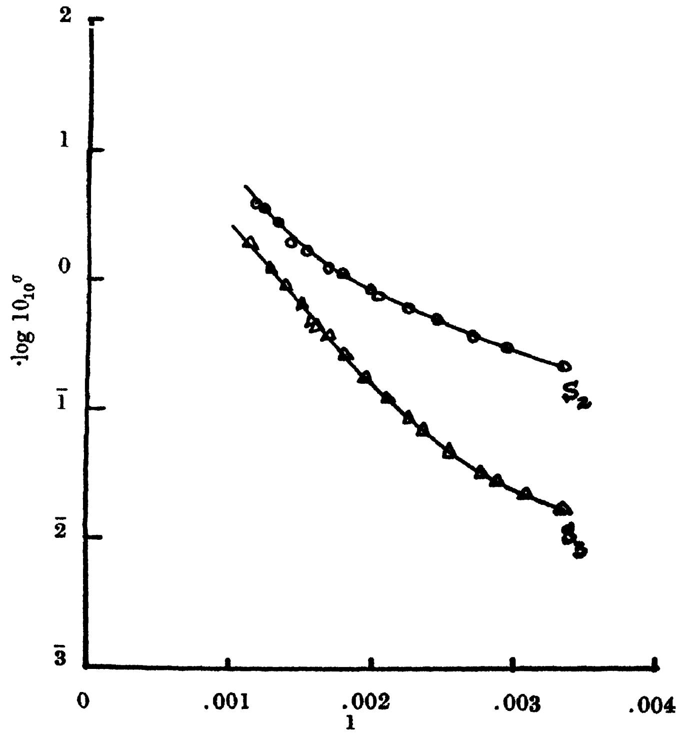

Fig. 4. Variation of conductivity with temperature for specimen S_2 and S_3

TABLE I

Samplo	Density gm/cm^3	Dimension cm	Conductivity at room temperature ohm^{-1} cm^{-1}
S_1	5.180	$2.154\times0.711\times0.52$	0.216
S_2	5.26	$1.099\times0.395\times0.216$	0.217
S_3	4.861	$1.924\times0.489\times0.349$	0.017

TABLE II

The values of W_1 and W_2

Sample	W_1 eV	W_2 eV
S_1	0.17	0.42
S_2	0.17	0.48
S_3	0.19	0.50

DISCUSSION

It is observed that both for extended as well as point contact, the current voltage characteristics are nonlinear and symmetrical. The non-ohmic nature increases with temperatures. No rectification occurs for point contact.

The electrical conductivity was calculated from the ohmic portion of the current voltage characteristics for low values of current and voltage.

The temperature variation conductivity plotted as $\log_{10}\sigma$ versus the inverse of temperature T°K shows two distinct linear portions, each of which can be fitted by a relation $\sigma = A \exp\ (-W/2kT)$ where the symbols have their usual significances. The values of activation energy W calculated for the specimens are listed in Table II. W_1 and W_2 refer to lower and higher temperature ranges of the curves.

Conductivity values of Kohnke (1952) at room temperature lie in the range 10^{-2} to 10^{-3} ohm^{-1} cm^{-1} whereas those of Lock (1963) lie in the range 10^{-1} to 10^2 ohm^{-1} cm^{-1} for doped specimen and is 10^{-2} for the undoped. Kohnke (1962) obtained 0.72 eV activation energy from the linear portion in the high temperature region for all three samples. No corresponding information is available from Locks's paper. Miloslavskii (1959) calculates an activation energy of 0.12 eV for thin films of stannic oxide in the same temperature range. These differences in the values of the conductivities and activation energies are due to differences in the origin, nature and previous history of the specimens used by different investigators.

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REFERENCES

Aitchison, R. E., 1954, *Aust. J. appl. Sci*, **5**, 10.
Bauer, G., 1937, *Ann. Phys. Lpz.* **3e**, 433.
Datta, A. K., 1953, *Phys. Rev.*, **90**, 187.
Fisher, A., 1954, *Z. Naturf.*, **9***A*, 508.
Foex, M., 1944, *Bull. Soc. Chim. Fr.*, **11**, 6.
Guillery, P., 1932, *Ann. Phys. Lpz.*, **14**, 216.
Ishigaro, K., Sasaki, T., Arai, T., and Imai, I. J., 1958, *J. Phys. Soc. Japan*, **13**, 296.
Kohnko, E. E., 1962, *J. Phys. Chem. Solids*, **23**, 1557.
Leblanc, M., and Sachse, H., 1931, *Phys. Z.* **32**, 887.
Lock, L. D., 1963, *J. Electrochemical. Soc.*, **110**, 1081.
Moloslavskii, V. K., and Lyashenko, S. P., 1960, *Opt. Spectroc*, **8**, 455.